PLAY HARD, SLEEP HARDER: RELATIONSHIP BETWEEN TIME SPENT PLAYING VIDEOGAMES AND SLEEP

A Thesis
by
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Abstract

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The use of electronics, including videogames, has been shown to affect sleep. However, previous results have been inconsistent. The current correlational study used a college-aged sample to look at how several variables (e.g., time spent playing videogames, morningness-eveningness, social goals/pressures, etc.) are related to aspects of sleep (i.e., sleep quality, sleep quantity, and sleep onset latency). Measures included the Pittsburg Sleep Quality Index (PSQI), the Morningness-Eveningness Questionnaire (MEQ), a sleep app, and sleep and videogame play diaries. Measures were used to collect data over the course of a three-day period. The diaries were designed to measure pre-bedtime videogame play – including social aspects of game play – each evening prior to sleep and to measure quality and quantity of sleep upon awakening. Hierarchical multiple regression models were used to test hypotheses. It was hypothesized that amount of time spent playing videogames and amount of gaming during the hour before bed (Step 2) would predict sleep quality, sleep quantity, and sleep onset latency, when controlling for PSQI and MEQ scores (Step 1). It was additionally hypothesized that social goals/pressures would moderate the relationships between the videogame and sleep variables (Step 3). However, no moderating effects were identified. Participant characteristics (i.e., PSQI scores) significantly predicted all sleep outcomes. Videogame variables only significantly predicted sleep onset latency, suggesting that the amount of time playing videogames had relatively no impact on sleep quality or quantity.

Keywords: sleep quality, sleep quantity, videogames, electronics, social pressure

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Abstract

The use of electronics, including videogames, has been shown to affect sleep. However, previous results have been inconsistent. The current correlational study used a college-aged sample to look at how several variables (e.g., time spent playing videogames, morningness-eveningness, social goals/pressures, etc.) are related to aspects of sleep (i.e., sleep quality, sleep quantity, and sleep onset latency). Measures included the Pittsburg Sleep Quality Index (PSQI), the Morningness-Eveningness Questionnaire (MEQ), a sleep app, and sleep and videogame play diaries. Measures were used to collect data over the course of a three-day period. The diaries were designed to measure pre-bedtime videogame play – including social aspects of game play – each evening prior to sleep and to measure quality and quantity of sleep upon awakening. Hierarchical multiple regression models were used to test hypotheses. It was hypothesized that amount of time spent playing videogames and amount of gaming during the hour before bed (Step 2) would predict sleep quality, sleep quantity, and sleep onset latency, when controlling for PSQI and MEQ scores (Step 1). It was additionally hypothesized that social goals/pressures would moderate the relationships between the videogame and sleep variables (Step 3). However, no moderating effects were identified. Participant characteristics (i.e., PSQI scores) significantly predicted all sleep outcomes. Videogame variables only significantly predicted sleep onset latency, suggesting that the amount of time playing videogames had relatively no impact on sleep quality or quantity.

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Play Hard, Sleep Harder: Relationship between Time Spent Playing Videogames and Sleep

In today's world, the presence of electronic media is pervasive. For example, computer ownership rose from 35% to 71% from 1998 to 2008 in Germany for individuals in the 12-19 year old age range, with game console ownership similarly increasing from 23% to 45% across this time period (Rehbein, Kleimann, & Mößle, 2010). In the U.S., in 65% of households at least one family member plays videogames regularly for at least 3 hrs each week (Entertainment Software Association, 2017b) and 72% of Americans report occasionally playing videogames (Roane, Morrissey, & Fernando, 2016). In the U.S., children report playing videogames for an average of 9 hrs each week and 70% of college students consider themselves to be avid gamers (Barlett, Anderson, & Swing, 2009). Electronics, including videogames, are often used in the bedroom, including before sleep. Chahal, Fung, Kuhle, and Veugelers (2013) found that 57% of Canadian children reported using electronic devices after their parents thought they had gone to bed. Research indicates that children sleep less than those of previous generations and often fail to meet their recommended nightly amount of sleep; more frequent electronic usage before bed is thought to contribute to this change in sleep patterns (Chahal et al., 2013; LeBourgeois et al., 2017).

While a variety of electronics, such as televisions, cell phones, and computers, can influence an individual's sleep, the current study focuses on the potential relationship between traditional (i.e., consoles and computers, but not cell phones) videogame play and sleep. The related literature regarding previous videogame research, electronic media use prior to bed, the affects of gameplay on sleep, the impact of social influences on game play, the role of chronotype on sleep and videogame play, and influences of light are discussed below.

Videogame Research

Videogames have become increasingly popular; currently over 150 million Americans engage in gaming (Entertainment Software Association, 2017c). Although in the past males made up the bulk of gamers, recently game developers have made efforts to create games that appeal to everyone; women now make up 41% of videogame players (Entertainment Software Association, 2017b; Lin, 2010). However, women play for shorter time periods than men. In addition, men are more likely than women to enjoy watching others play without participating in gaming themselves (Ogletree & Drake, 2007). Men consider videogames to be more important to them than do women. Men prefer action and fighting games, whereas women prefer puzzle, dance, and simulation games (Phan, Jardina, & Hoyle, 2012).

Since playing videogames is more commonplace today than in the past, they are less of a niche entertainment interest. For example, many educational programs incorporate videogames as a means of increasing learning and to make topics more fun (National Public Radio, 2010). A game developed by iCivic – *Win the White House* – helps to educate students about politics by teaching them about the roles of the government (Entertainment Software Association, 2017a). Some workplaces use videogames to train new employees, creating a more engaging environment. The medical field has used videogames to both rehabilitate patients and to train medical residents to perform medical procedures in virtual environments (Entertainment Software Association, 2017c).

Given the popularity of videogames, there has been increased interest in examining their impact on affect, behavior, and cognition. Some studies have focused on the positive affects of videogame exposure on outcomes. For example, Hamlen (2013) reports that videogame play relates to a decrease in depressive symptoms and improved problem-solving abilities. Researchers have also found positive correlations between videogame play and improved visual attention, spatial abilities, and performance in academic areas such as math and vocabulary (Barlett et al., 2009).

More often research has focused on potential negative outcomes of violent videogame play, including negative affect and aggression (Anderson & Bushman, 2001). Most children who play videogames (59% of girls and 73% of boys) reported that their favorite games were violent (Anderson & Bushman, 2001). Lemmens, Valkenburg, and Peter (2011) found that both men and women exhibit similar negative effects after playing violent videogames and posit that pathological gaming is more likely to be related to potential negative effects. In their General Aggression Model (GAM), Anderson and colleagues argue that exposure to violent media primes aggressive cognitions and can lead to the activation of aggressive thoughts and scripts, increased feelings of anger and hostility, and decreased prosocial behavior (Anderson & Bushman, 2001; Barlett et al., 2009). They also argue that a desensitizing effect occurs as a result of frequent exposure to violent videogames, rendering those who are exposed to high levels of media violence less physiologically and affectively responsive to real world violence (Anderson & Bushman, 2001).

Read, Ballard, Emery, and Bazzini (2016) tested the GAM to examine if violent videogame play led to desensitization to violent images. Participants played either a violent or non-violent videogame. Following game play, participants' heart rate (HR) and blood pressure (BP) were measured. Participants then viewed a series of pleasant, neutral, and aggressive images on a computer screen while electromyography (EMG) was used to measure muscle movements in the corrugator supercilii (which furrows the brow during the expression of negative emotion). Self-reported emotional reactivity and arousal were also recorded. Read and colleagues (2016) found no evidence of desensitization with regard to affective, cognitive, or physiological (EMG, HR, or BR) responding to the violent images.

A study conducted by Ballard, Visser, and Jocoy (2012) looked at the impact of both violent videogame play and social context on aggression. They compared the affects of solitary, cooperative, and competitive gameplay on affective and physiological responding. Participants reported greater frustration when playing competitively compared to individually or cooperatively, but frustration was higher when playing alone than when playing cooperatively (Ballard et al., 2012). Further, participants reported more positive affect (i.e., less stress and more excitement) after playing the violent videogame than after playing the non-violent videogame. Both of these studies by Ballard and colleagues (Ballard et al., 2012; Read et al., 2016) fail to support the GAM.

Ferguson and colleagues (2015) conducted a series of studies to examine the affects of violent videogames on children. In one study, they had 70 children play either a violent or non-violent videogame and complete an aggression questionnaire. There were no significant differences in aggressive behaviors for game condition or gender. In Study 2, they focused on narrative driven games to see if this game type led to increased immersion and aggression. The results were non-significant across all conditions. In a third study, they used a survey to examine the relationship between violent videogame play and real world aggressive behaviors. There was no significant relationship between violent videogames and either criminal behaviors or civic behavior (Ferguson et al., 2015).

In sum, the literature regarding the positive and negative outcomes of exposure to violent videogames on positive and negative social behaviors and on physiological responding is inconsistent. Similarly, research regarding the impact of videogames and other electronics on sleep, reviewed below, yields mixed results.

Electronics and Sleep

In general, most of the extant literature focuses broadly on the degree to which electronic media may influence an individual's sleep. Computer use and television viewing are of primary concern, due to the prominence of these devices in the bedroom. A recent study found that among Belgian children aged 8-18, 71% have a television and about half have a gaming device in their bedroom (Pieters et al., 2014). Other findings indicate that, in the U.K., portable game consoles are present in the bedrooms of children aged 11-13 83% of the time and standard game consoles are present 44.7% of the time (Arora, Broglia, Thomas, & Taheri, 2014). In the U.S., screen-based electronic media are present in the bedrooms of approximately 75% of children aged 6-17, with roughly 60% of adolescents reporting using these devices during the hour before bed (Buxton et al., 2015; Hysing et al., 2015).

Individuals with a television in the bedroom are estimated to delay bedtime and stay awake for an extra hour compared to people without a television in their bedroom (Pieters et al., 2014). Spending more time using any kind of electronic device before bed has been associated with later sleep onset. Older adolescents, particularly males, are more likely to use electronics leading up to bedtime (Foley et al., 2013). Additionally, having more electronic devices in the bedroom was found to result in shorter sleep duration, with children reporting less sleep on nights when electronics were used (Arora et al., 2014; Chahal et al., 2013). Older adolescents often require more time to exhibit the effects of sleep deprivation from continuous delays in bedtime than children, suggesting they may be less susceptible to changes in their sleep patterns as a result of engaging in the use of electronics before bed

(Pieters et al., 2014). Younger children are believed to be more strongly affected by videogame play before bed, although this may be a result of playing more frequently (Milada et al., 2011).

The use of screen-based media has also been linked with ratings of tiredness. However, this relationship seems to be dependent on age (Basner, Spaeth, & Dinges, 2014). Adults are less likely than children to report tiredness. This is likely due to adults being more able to compensate for changes in sleep patterns by increasing total sleeping time than children, who may be unable to make up for lost sleep due to their daily schedules being dictated by other people and events (e.g., school) in their lives (Higuchi, Nagafuchi, Lee, & Harada, 2014).

When looking at the specific impact of electronic devices, such as e-readers, on sleep outcomes, Chang, Aeschbach, Duffy, and Czeisler (2015) found that using these devices led to increased sleep onset latency (SOL) and reductions in total rapid eye movement (REM) sleep. These outcomes were more pronounced than when reading traditional print books. They also found evidence of reduced melatonin secretion and a delayed circadian clock in people who read using an e-reader compared to those who read using a traditional print book. These results suggest that suppression of melatonin occurs as a result of pre-bedtime electronic usage.

Mesquita and Reimão (2010) focused specifically on the nighttime use of electronic devices and sleep habits in university-aged students. A majority (60%) of participants identified themselves as poor sleepers. Nighttime computer use was more common than television viewing, with men staying up later to use a computer than women. Participants who reported computer use from 7:00 p.m. – 12:00 a.m. were more likely to identify themselves as a poor sleeper. This effect was not observed for individuals who watched TV during this time. The authors conjecture that sleep disturbances are more pronounced after using a computer than after watching TV due to the nature of the engagement with the device. Using a computer requires the user to be more actively involved and requires a higher level of attention, while watching TV is typically more passive (Mesquita & Reimão, 2010). These results suggest that different electronic devices may impact sleep to varying degrees.

Videogames and Sleep

While most of the literature on electronics and sleep has focused on the use of computers, cell phones, or televisions prior to sleep, the focus of the current study is to examine how traditional videogame play relates to sleep. Roane and colleagues (2016) report that a majority (90%) of Americans fail to get the recommended amount of sleep and suggested that videogame play may account for sleep displacement and reduced sleep duration for many of these Americans. Some studies find that videogame play is relatively common before bed. Pieters and colleagues (2014) found that 36% of participants reported playing videogames in the hour before bed. Foley et al. (2013) found that children were more likely to report television viewing (61%) and computer usage (6%) than videogame play (5%) before bed, but that videogame play was a common pre-bedtime activity.

There are inconsistent findings regarding the impact of videogame play on sleep. Some research indicates that videogame play is associated with frequent awakenings, a reduction in sleep duration, longer SOL, parasomnias, inability to fall asleep, and difficulty in remaining asleep, while other studies fail to find similar relationships (Arora et al., 2014).

Ogletree and Drake (2007) found that men were significantly more likely than women to report that videogame play interfered with their sleep.

In a correlational study by Arora and colleagues (2014), children aged 11-13 from the U.K. were given the School Sleep Habits Survey and Technology Use Questionnaire and reported on electronic media usage and a variety of sleep behaviors. Arora et al. (2014) found that playing videogames before going to bed was associated with significantly longer SOLs and difficulty falling asleep. Children also reported that frequent gaming made it difficult to “switch off the mind,” making sleep more difficult (Arora et al., 2014).

In an experimental study, Weaver, Gradisar, Dohnt, Lovato, and Douglas (2010) had male participants aged 14-18 play *Call of Duty* for 50 min one night prior to bedtime and had them watch *March of the Penguins* for 50 min on another night prior to bedtime. The conditions were counterbalanced; participants completed both conditions one week apart. Participants kept a daily sleep diary for the week prior to the study to establish baseline sleeping habits and during the week between testing sessions (Weaver et al., 2010). Participants also completed the Stanford Sleepiness Scale (SSS) after each media condition. They found no significant differences between the conditions for either the duration of the first period of REM sleep or the total percentage of REM sleep. They did find a significant increase in SOL for the videogame condition as compared to the TV condition, but noted that the observed increase in SOL (< 10 min) after videogame play was relatively small compared to the findings of Dworak, Schierl, Bruns, and Strüder (2007), where an increase of 21.7 min was observed in SOL. Weaver et al. (2010) conjectured that their findings differed from previous studies (i.e., Arora et al., 2014; Dworak et al., 2007), because they recruited “well-trained” sleepers. By excluding poor sleepers from their sample, their participants might not have been representative of the typical person, resulting in less impact on the participants' SOL than in other studies.

Wolfe and colleagues (2014) also failed to find a direct effect of videogame play on sleep. In this study, participants aged 15-20 came into the lab and played *Bioshock Infinite* starting at 8:00 p.m., for as long as they desired, until 1:00 a.m. Participants slept in the lab and were awoken at 7:00 a.m. the following morning. Upon awakening, they completed measures of working memory and sustained attention. Wolfe and colleagues (2014) found that male participants and younger participants played the game significantly longer and obtained significantly less sleep than female participants and older adolescents, but that videogame play per se did not significantly affect participants' SOL (Wolfe et al., 2014). Thus, participants' sleep duration was affected by displacement of sleep due to game play, rather than taking longer to fall asleep following game play. These findings are consistent with the results of Milada and colleagues (2011), who found that spending more time playing videogames before bed was related to later bed times and later awakenings and Rehbein and colleagues (2010), who found that males were more likely to report that game play impacted sleep onset due to displacement. In terms of cognitive functioning, Wolfe and colleagues (2014) did find that shorter sleep durations were significantly negatively correlated with sustained attention.

In an experimental study by Ivarsson, Anderson, Åkerstedt, and Lindblad (2013), Swedish boys aged 13-16 were recruited to play a violent and non-violent videogame and were grouped based on the amount of time that they typically spent gaming. Half of the participants were considered high-exposure (played at least 3 hrs daily) participants and the other half were considered low-exposure (played up to 1 hr daily) participants. Participants played both the violent and non-violent game, in a counterbalanced fashion, on two separate nights in their own home. The videogames were played between 8:00 p.m. and 10:00 p.m. without breaks, with bedtime occurring at 10:30 p.m. Ivarsson et al. (2013) found that boys in the high-exposure group reported a shorter SOL and reported feeling significantly more alert when awakening in the morning than those in the low-exposure group, regardless of game content. These findings are similar to those of Pieters et al. (2014) who found that individuals who reported more game play prior to bedtime reported feeling less sleepy on the weekends as compared to weekdays and were more likely to perceive they had achieved enough sleep. Although Ivarsson and colleagues (2013) did not report any main effects of game content, there was an interaction between content and group; for the low-exposure group sleep quality was lower for participants who played a violent videogame versus a non-violent game, with the opposite being true for the high-exposure group (Ivarsson et al., 2013). Ivarsson et al. (2013) suggested that those in the high-exposure group may have became desensitized to the physiological effects of the violent videogame, resulting in less arousal before bedtime, while those in the low-exposure group did not spend enough time gaming for desensitization to occur.

King et al. (2013) also used an experimental design to look at the short-term effects of violent videogame play on sleep. In their study, male participants age 15-17 played *Warhammer 40,000: Space Marine* for 50 min on one night and for 150 min on another night, one week apart in a counterbalanced order. Findings indicated that participants' subjective excitement after playing the game was significantly positively correlated with subjective SOL. In the 50 min condition, but not the 150 min condition, participants' reported desire to continue playing was significantly positively correlated with subjective and objective SOL, but not subjective sleepiness. Thus, truncating game play earlier than desired might interfere with sleep onset. However, there were no significant main effects of the time of play condition on total sleep, sleep efficiency, or subjective SOL (King et al., 2013).

Roane et al. (2016) had 963 gamers complete an online survey to assess the extent to which gaming habits influenced bedtime delays. Consistent with the findings reported above, they found that 67% of gamers reported delaying their bedtime in order to continue playing videogames. In addition, 41% of participants reported being late to school, work, or some other activity the following day as a result. Participants who reported more frequent gaming were more likely to delay their sleep, particularly when playing social games (i.e., cooperative or multiplayer; Roane et al., 2016), suggesting that delays in bedtimes is tied to videogame play.

In sum, research examining the relationship between sleep and videogames has produced mixed results. Some research shows that playing videogames for longer periods of time and/or prior to bedtime is correlated with increases in SOL (Arora et al., 2014). However other studies did not find increased SOL after game play (Weaver et al., 2010; Wolfe et al., 2014). Ivarsson and colleagues (2013) argue that lengthy game play may desensitize players and result in less impact on sleep. Other research indicates that time displacement that results in going to bed later, rather than difficulty falling asleep once in bed, better explains the impact of evening videogame play on sleep (Milada et al., 2011; Roane et al., 2016). Longer playing times, as well as engaging in gameplay with others is a possible explanation as to why delays in bedtime may be more likely to occur.

Social Influences

When playing videogames, gamers may choose to play alone or with others in groups, either in person or online. According to a report by the Entertainment Software Association (2017b), 53% of gamers play socially oriented games. In the present study social gaming is operationalized as playing videogames with others.

Playing with others may alter a player's behavior, so this topic needs to be further explored. For some players the social aspect of gameplay is what they find most enjoyable, in particular, immersive online games facilitate a high degree of social engagement (Dalisay, Kushin, Yamamoto, Liu, & Skalski, 2015). This may explain why massively multiplayer online role-playing games (MMORPGs) have been referred to as an informal social hub similar to a coffee shop or bar (Zhang & Kaufman, 2015). People who are more attracted to videogame play due to their social nature are at an increased risk for gaming habits that interfere with daily life (Snodgrass, Lacy, Dengah, & Fagan, 2011). For these players, videogames may take precedence over their real life relationships and other responsibilities. While the high levels of engagement with in-game communities in MMORPG play can be positive, sometimes it places players at increased risk for experiencing time displacement (Snodgrass, Dengah, Lacy, & Fagan, 2013).

In addition to social interaction, people play videogames to pass the time, to relax, and/or as an outlet when real world challenges cannot be handled directly (e.g., problems at work and unable to lash out at boss; Dalisay et al., 2015; Stavropoulos, Kuss, Griffiths, Wilson, & Motti-Stefanidi, 2017). While gaming is typically a hobby that occupies limited free time, some individuals, particularly males and people between the ages of 18-35, are at increased risk for excessive videogame play (Entertainment Software Association, 2017b).

While few people play videogames excessively, excessive play can negatively impact romantic relationships and performance in school and work environments (King & Delfabbro, 2009; Snodgrass et al., 2011). In order to understand why people play videogames excessively, studies typically focus on factors that motivate videogame play.

To assess factors related to excessive gameplay, King and Delfabbro (2009) conducted a series of group interviews in which they probed adolescent and adult gamers of both genders about why they were motivated to play videogames. In terms of social factors, many participants reported that other players discouraged them from spending time outside of the game or ending a session prematurely (e.g., quitting the game when other players need your help). Players often claimed that stopping gameplay too early leads to rumination about unfinished tasks in the game or guilt related to fearing that they let other players down (King & Delfabbro, 2009).

Engaging in cooperative tasks, such as completing "raids," often requires large amounts of player time, places a heavy demand on a player, and may be stress inducing (Snodgrass et al., 2011). Snodgrass and colleagues (2011) report that increased reliance on other players may encourage people to play videogames for longer periods of time in order to continue experiencing in-game success. Subsequently, players may have difficulty regulating how long they play, resulting in time displacement that results in putting off sleep. For example, Zhang and Kaufman (2016) found that 11.2% of participants reported sleeping less to spend more time playing with others online.

Tan, Yeh, and Chen (2017) studied the role of negotiation strategies and motivational factors as related to videogame play. Sometimes when people play videogames they have other responsibilities (e.g., household chores or work-related tasks) that need attention.

Some players use negotiation strategies to reduce the impact that these time constraints have on playing videogames (Tan et al., 2017). Cognitive negotiation strategies involve reframing leisure activities to be more important than they actually are to justify engaging in the leisure activity as opposed to other, more legitimate, responsibilities. Behavioral strategies involve accommodating the leisure activity by adjusting other daily obligations or activities, or by altering the leisure activity itself. This includes using time management strategies (Tan et al., 2017) such as delaying bedtimes. Immersion, achievement, and social motivations also impact length of gameplay (Tan et al., 2017). For example, deeply immersed players sometimes report that they “lose themselves” during gameplay. Some become so dissociated from reality that they are unaware of the events around them, resulting in time displacement (Snodgrass et al., 2013).

The current study examines how the social goals and pressures that gamers may experience impacts their gameplay and, subsequently, their sleep. Social goals refer to activities that players may engage in with others that promote cooperation or camaraderie (e.g., wanting to continue playing due to having a good time with others; Tan et al., 2017). Social goals suggest positive social interactions. Social pressures, on the other hand, refer to players feeling obligated to continue playing, even if they express a desire to quit (e.g., not wanting to let other players down). This concept has a more negative connotation. Although social goals and pressures may both be related to time displacement and reductions in sleep quality and quantity, there are currently no studies that examine these factors.

While excessive videogame play may result in negative outcomes (e.g., spending less time with family, not getting work or chores completed), playing videogames that require cooperation with other players can yield positive results. Playing with others can supplement face-to-face interactions, allowing players to socialize with real-life friends; 41% of players report playing videogames with friends and 21% report playing with family (Entertainment Software Association, 2017b; Stavropoulos et al., 2017). Similarly, Zhang and Kaufman (2016) found that 45% of players in their study agreed or strongly agreed that playing with real-life friends or family helped them to feel closer to them.

Some researchers have examined playing videogames across a variety of relationships. Zhang and Kaufman (2015) looked at social capital, components of an individual's social life that promote cooperation that results in mutual benefit. Zhang and Kaufman (2015) examined two types of social capital, bridging social capital (weak social ties between individuals with different backgrounds) and bonding social capital (close networks between people with similar backgrounds and beliefs that create strong personal connections) among middle-aged participants when playing WoW (Zhang & Kaufman, 2015). Most male (76%) and female (75%) participants reported having made "good friends" in the game. A majority (67%) reported that they developed positive relationships with other players in the game. In fact, 40% of male and 53% of female players rated their in-game friends as comparable to their real-life friends (Zhang & Kaufman, 2015). Since participants reported strong, positive relationships with other players, this may help explain why players spend more time playing videogames in a social setting rather than spending time alone. This, in turn, may put players at an increased risk of experiencing time displacement and achieving less sleep.

There is currently limited research on how social influences are related to videogame play. Most studies focus on MMORPG play and how areas of players' lives are impacted (e.g., relationships, school, work, etc.). There are no cogent studies examining how social interactions may moderate the relationship between videogames and sleep. Studies addressing this topic are needed. The current study will focus on how social goals/pressures may be related to longer videogame play, shorter sleeping times, and worse sleep quality.

Chronotype

Sleep outcomes are also influenced by individual differences such as chronotypes, which are individual circadian rhythms that dictate when an individual sleeps. Chronotype is typically measured using a morningness-eveningness questionnaire and individuals are categorized as morning type, evening type, or neither type. Morning type persons typically report earlier bedtimes and wake times and experience optimal performance earlier in the day (Horne, Brass, & Petitt, 1980). Evening type persons, on the other hand, report later bedtimes and wake times and perform better later in the evening. Sleep difficulties that an individual may experience sometimes also differ by chronotype. Morning people report more difficulty remaining asleep, while evening people report more difficulty initiating sleep (Taillard, Phillip, Chastang, Diefenbach, & Bioulac, 2001). Evening type people also report worse sleep quality on the Pittsburg Sleep Quality Index (PSQI; Barclay, Eley, Buysse, Archer, & Gregory, 2010). One study that examined chronotypes found that most people are not classified as either type (Vitale et al., 2015) and that people become more morning type as they age (Kim et al., 2010). Gender differences have also been observed; a higher proportion of males are categorized as evening type and more females are categorized as morning type (Adan & Natale, 2002). Additionally, people born during fall and winter are more likely to be identified as morning type, while people born during spring and summer are more likely to be identified as evening type (Mongrain, Paquet, & Dumont, 2006).

A study conducted by Vitale and colleagues (2015) used a college-aged sample to compare chronotype identity and sleep data, obtained through the use of actigraphy (i.e., a measure of sleep tied to movement), over the course of a seven-day period. Many of their results aligned with previous findings; morning type persons reported better sleep quality on weekdays than evening type or neither type persons. However, evening types experienced similar sleep quality compared to morning types on the weekend. Vitale et al. (2015) hypothesized that evening type people accrue a sleep debt over the course of the week due to daily responsibilities (e.g., work, school) and attempt to account for "lost" sleep during the weekend.

Chronotype may also play a role in the relationship between videogame play and sleep. Milada and colleagues (2011) surveyed mothers of 497 Czech and 599 Japanese children aged 2-6 to examine how playing videogames was associated with sleep-wake cycles. They assessed morningness/eveningness, average bedtimes, average wake times, and videogame habits. Czech children were more likely to be identified as morning type and have better sleep quality and quantity. Japanese children were more likely to be identified as evening type and demonstrate poorer sleep quality and quantity. This effect was more pronounced among frequent gamers (Milada et al., 2011). Children from both countries who were identified as gamers were more likely to be evening type and have later bedtimes and wake times than non-gamers. Play times longer than 30 min were tied to significantly later bedtimes and wake times, particularly when children played after sunset (Milada et al., 2011). The results of these studies indicate that chronotype, as identified through morningness-eveningness scores, may moderate the relationship between playing videogames and sleep outcomes.

Light and Sleep

One of the factors hypothesized to link electronic use – including videogame play – and sleep is light. Blue light is prevalent in electronic devices such as computers and videogame consoles and has been shown to suppress melatonin production and promote alertness in adults (LeBourgeois et al., 2017; Vollmer, Michel, & Randler, 2012). Blue light exposure also correlates with eveningness, suggesting that increased electronic use may shift the circadian cycle.

A study by Figueiro, Bierman, Plitnick, and Rea (2009) looked into the role of differing levels of either blue or red light on inducing alertness at night. Participants were exposed to blue or red light at two levels (low amount and high amount) for 45 min in a counterbalanced fashion; a 45 min dark period occurred before each testing session. During the course of the experiment, participants reported their subjective sleepiness and completed three tasks (simple reaction time test, two choice reaction time test, and matching to sample test) during each light and dark exposure trial (Figueiro et al., 2009). Participants' brain waves were recorded through the use of electroencephalography (EEG). Participants provided saliva samples to determine melatonin levels. There were no main effects of type or level of light on EEG or melatonin levels, but exposure to the high level of blue light suppressed melatonin production significantly more than the other conditions. Additionally, participants became increasingly sleepier over time regardless of light type and current level of exposure. Both types of light were found to be equally effective in promoting alertness (Figueiro et al., 2009).

Van der Lely et al. (2015) examined the role of LED devices on alertness since these devices emit higher proportions of short-wavelength (i.e., blue) light. Male adolescents spent one week wearing either blue blocking or clear glasses during the evenings. The participants maintained a sleep diary and sleep data was collected via an actigraph. At the conclusion of the week, participants visited the lab to complete cognitive tasks on bright LED screens in both a dim and a dark room prior to bedtime. They reported their subjective sleepiness at 30 min intervals. Polysomnographic measures of their sleep were collected, they reported on their sleep quality in the morning, and saliva samples were gathered. Van der Lely and colleagues (2015) found that participants in the blue blocking condition rated themselves as significantly sleepier than the participants who wore the clear glasses. Participants in the blue blocking condition also had significantly higher levels of melatonin 5-90 min before bedtime. There were no main effects of condition for rates of sleepiness in the morning or EEG measures.

Other artificial light also influences sleep behaviors, although not as strongly as blue light. Many studies addressing the role of light address its relationship with alertness and the relationship with sleep is often inferred from this data (Figueiro et al., 2009). More studies should be conducted to assess direct links between sleep and other types of artificial light.

Vollmer et al. (2012) argued that artificial outdoor lighting may encourage eveningness by increasing outdoor activities after sunset. Similarly, Mesquita and Reimão (2010) found that exposure to artificial light prior to 12:00 a.m. delayed the circadian phase, while exposure after 12:00 a.m. advanced the circadian phase. There may also be a seasonal link with chronotype, with later sunrises being linked with more reports of eveningness (Vollmer et al., 2012).

There are other individual and contextual differences in whether or not light negatively affects sleeps. For example, children are more sensitive to light exposure prior to sleep than adolescents and adults (Milada et al., 2011). This increased sensitivity to light exposure is partly explained by the fact that they possess larger pupils and have an increased light transmission rate of the crystal lens (Turner & Mainster, 2008). Honma and Honma (1988) argue that exposure to light from videogames may delay the circadian rhythms of children. This could be true, as children have been shown to suppress double the amount of melatonin as adults when exposed to varying levels of light for a 1 hr period over the course of several nights (Crowley, Cain, Burns, Acebo, & Carskadon, 2015). Consistent with this, Milada and colleagues' (2011) findings suggest that videogame play in the evening affects children more than adolescents and adults.

Only a few studies have examined the impact of light levels in videogame play on sleep. Higuchi, Motohashi, Liu, and Maeda (2005) had adult male participants play a shooter computer game in front of either a bright or dim computer display. Participants also performed low cognitive load tasks in front of the bright or dim display as a control. They found a main effect of task type, with participants having significantly longer SOLs after playing the computer game than after completing the control task. Total REM sleep was also shorter during the first sleep cycle following game play than after the control task, but was normal for all subsequent cycles as indicated through the use of EEG. These findings are inconsistent with those of Weaver et al. (2010), who found that REM sleep was not affected by videogame play. Higuchi and colleagues (2005) found no main effects for computer display brightness on total sleep time (TST), movement time, REM latency, sleep efficiency, total time spent asleep, waking time, or subjective sleepiness. Participants who played the computer game in the bright display condition, however, did report lower sleep quality (Higuchi et al., 2005).

Current Study

The literature examining the relationship between videogame play and sleep is limited. Lab studies often limit the amount of videogame play time, have pre-established bedtimes and wake times, and only collect data across one or two days with large delays between testing periods. These methods are likely to result in game play behaviors – including social interactions – and sleep patterns that differ from participants' typical schedule of game play and sleep. To obtain more thorough and reliable data regarding participants' typical patterns of videogame play and sleep, this study had participants report videogame play and sleep at home across a three-day, consecutive period.

This correlational study examined whether the amount of time spent playing videogames in traditional contexts and the amount of time spent gaming during the hour before bed predicted college students' sleep quality, sleep quantity, and SOL after controlling for the participants' sleep quality history and level of morningness-eveningness. In terms of the potential impact that social gaming may have on sleep, data regarding social goals and social pressures related to playing videogames with others (e.g., wanting to make new friends or people urging them to continue playing) was collected to examine if this moderated the relationship between videogame play and sleep variables (i.e., sleep quality, sleep quantity, and SOL; see Figure 1). It was expected that the relationship between videogame use and sleep outcomes would be stronger for participants who reported social goals and/or social pressures compared to participants who did not, with social gaming being more strongly associated with worse sleep outcomes.

Hypotheses

Hypothesis 1. Time spent playing videogames across the day and time spent playing videogames in the hour before bed was expected to predict sleep quality after controlling for sleep quality history and morningness/eveningness. Social influences (i.e., social goals/social pressures) were predicted to moderate this relationship.

Hypothesis 2. Time spent playing videogames across the day and time spent playing videogames in the hour before bed was expected to predict sleep quantity after controlling for sleep quality history and morningness/eveningness. Social influences (i.e., social goals/social pressures) were predicted to moderate this relationship.

Hypothesis 3. Time spent playing videogames across the day and time spent playing videogames in the hour before bed was expected to predict SOL after controlling for sleep quality history and morningness/eveningness. Social influences (i.e., social goals/social pressures) were predicted to moderate this relationship.

Method

Participants

Participants consisted of 99 college students [male (n = 34) and female (n = 65)] between the ages of 18 and 22 years from Appalachian State University (M_{age} = 19.24, SD = 1.02). Most (n = 86) participants were White; the rest identified as Hispanic American (n = 7), African American (n = 3), Asian American (n = 2), or other (multiracial; n = 1). Participants were recruited through the SONA system, an online participant management system that allows students to participate in and receive course credit for research studies.

Reasonable alternatives for credit other than research participation were offered in the courses.

To be eligible for the study, participants had to meet certain inclusion criteria (see below and in Appendix A). Data was removed from analyses for participants who did not provide data for all three days of the study; there was a 24 hr period to report for each day. Nineteen participants were excluded for not completing all surveys. An additional participant was excluded for illogical responding. This resulted in a final sample of 80 participants [male (n = 29) and female (n = 51)]. An a priori power analysis indicated that a sample of at least 82 would be required to detect the correlational relationships found in previous research (r = .30, α = .05, β = .20, two-tailed). An r-value of r = .30 was chosen based on previous studies (Arora et al., 2014; King et al., 2013; Pieters et al., 2014; Wolfe et al., 2014) assessing relationships between similar videogame and sleep variables, with reported values ranging from r = .08 to r = .49.

Descriptive statistics for participants are provided in Table 1. Participants reported spending an average of 60.50 min playing videogames each day (SD = 86.12) with an average of 2.37 min during the hour before bed (SD = 7.21). This was significantly lower than the reported average daily playing time at baseline (M = 78.45, SD = 86.14) assessed during the lab visit, $t(79) = 2.28$, $p = .025$. There were more gamers (i.e., people who reported playing videogames; 59%) than non-gamers (i.e., people who did not report playing videogames; 41%) in the sample. Few participants reported experiencing social goals (M = .06, SD = .20) or social pressures (M = .01, SD = .04) while gaming.

Male participants played videogames significantly longer ($t(78) = 4.44$, $p < .001$) and spent significantly more time playing videogames during the hour before bed than female participants, $t(78) = 2.05$, $p = .044$. Female participants were significantly less likely to report playing videogames than male participants, $t(78) = 2.93$, $p = .004$. They also experienced significantly fewer social goals, $t(78) = 2.40$, $p = .019$.

All participants were identified as poor sleepers based on PSQI scores (PSQI > 5) with an average cumulative score of 9.21 (*SD* = 1.93). Participant scores ranged from 6-17. Thirteen percent of the sample had a score close to the poor sleeper cutoff (PSQI scores between 6-7). The majority (72%) of the sample had moderately poor sleep quality (PSQI scores between 8-10). The average MEQ score was 47.61 (*SD* = 7.75), with most participants being classified as “neither type” (67.5%), followed by “moderately evening type” (25%) and “moderately morning type” (7.5%). Self-report data indicated an average sleep quality of 3.15 (*SD* = .80), average sleep quantity of 449.40 min (*SD* = 102.26), and average SOL of 26.36 min (*SD* = 15.91).

Materials

Screening survey. A six-question screening survey was administered to interested participants through the online participant pool (SONA) to determine if participants met the inclusion criteria for the study: (a) they owned a smartphone capable of downloading the required app, (b) they were willing to download the app required for the study, (c) they were not using a sleep aid, (d) they had not been diagnosed with a sleep-related disorder, (e) they did not share a bed with another individual, and (f) they had a relatively normal sleeping pattern (defined as going to bed and waking up the next day within an hour of when they normally would for most nights). See Appendix A for questions. If potential participants met the criteria, they were invited to sign up for the study.

Demographics survey. A six-question survey was administered online through Qualtrics to obtain information regarding participants' age, self-identified gender, and race/ethnicity and to establish baseline videogame habits for participants prior to the start of the study (see Appendix B). Videogame playing time was reported in total minutes. These questions were administered through an online Qualtrics survey.

Pittsburg Sleep Quality Index (PSQI). The PSQI is an 11-question self-report survey designed to assess average sleep habits and sleep disturbances during the past month (The American Thoracic Society, 2015; see Appendix C). The PSQI includes questions about quantitative aspects of sleep such as bedtime, sleep duration, SOL, number of arousals, and depth or restfulness of sleep (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989). Other questions gather information regarding sleeping arrangements and sleep disturbances. Question response styles vary from open-ended input in the form of times ("During the past month, what time have you usually gotten up in the morning?") to a selection of responses that best describe the individual ("During the past month, how often have you had trouble sleeping because you . . ."; Buysse et al., 1989; The American Thoracic Society, 2015). For this study, only the first nine questions were used since the remaining two are not incorporated into scoring criteria.

The PSQI has a test-retest reliability of $r = .85$ over a period of several weeks and internal consistency with a Cronbach's alpha of .83 (The American Thoracic Society, 2015). The measure has concurrent and discriminate validity, displaying strong correlations with other clinical measures of sleep. It is also correlated with self-report measures of sleep quality, but not to actigraphy or polysomnography measures (Buysse et al., 2008). Other studies found that participants often self-report sleeping for longer periods on the PSQI compared to total sleep measured by actigraphs (Lauderdale, Knutson, Yan, Liu, & Rathouz, 2008). Pilcher, Ginter, and Sadowsky (1997) found that PSQI scores were more strongly correlated with sleep quality than sleep quantity. The PSQI can accurately differentiate between good sleepers and those who experience sleep disruptions due to a major depressive disorder or a diagnosable sleep disorder (Buysse et al., 2008). The PSQI produces average monthly scores that are stable over time but, since an average over time is used, it is not sensitive to daily variability (Buysse et al., 1989).

The PSQI has seven subscale scores and a total score. Subscales include: (a) duration of sleep, (b) sleep disturbance, (c) sleep latency, (d) day dysfunction due to sleepiness, (e) sleep efficiency, (f) overall sleep quality, and (g) need meds to sleep. Coding of values for each subscale range between zero (better sleep quality) and three (worse sleep quality). All of the subscales are added together to create a total score that ranges from 0 (better sleep quality) to 21 (worst possible rating for sleep quality). However, a total score greater than five indicates poor sleep quality. In the current study, the total score for the PSQI was used in the analyses. This measure was administered online through Qualtrics.

Morningness-Eveningness Questionnaire (MEQ). The MEQ is a 19-question self-report survey used to determine morningness/eveningness (i.e., chronotype). Participants are classified as one of five morningness-eveningness types, ranging from definitely evening type to definitely morning type on a 16-86 point scale (Lam, 2009; The American Thoracic Society, 2015; see Appendix D). Morning type individuals report earlier bedtimes and wake times and higher energy during the earlier part of the day. Evening type individuals report later bedtimes and wake times and higher energy during the latter part of the day (Vitale et al., 2015). The MEQ has good internal consistency with a Cronbach’s alpha of .83 (The

American Thoracic Society, 2015). Validity for this questionnaire was originally obtained through comparisons with oral temperatures as morning and evening type individuals experience peak body temperatures at different times.

Lower scores on the MEQ indicate eveningness and higher scores indicate morningness. Coding of responses for each question vary across items; coded values for each question are added together to create the final score. Total summed scores are broken down into categories, including: definitely evening type (score 16-30), moderately evening type (score 31-41), neither type (score 42-58), moderately morning type (score 59-69), and definitely morning type (score 70-86). Cumulative MEQ score was used in the hierarchical regression analyses. This measure was administered online through Qualtrics.

Daily videogame questionnaire. Participants answered nine questions regarding their videogame habits for each day of their participation. Examples of these questions include "How much time (in minutes) did you spend playing videogames today?" and "Did you delay your bedtime in order to play videogames?" Participants were instructed that smartphone games were not considered videogames in the current study. All other videogame platforms were treated as videogames and were not classified into separate categories. In addition, several questions were asked to determine the extent to which playing videogames with others (social goals and social pressures) was associated with gaming and sleep variables. Social goals were defined as players engaging in play with others that promote cooperation or camaraderie, while social pressures were defined as players feeling obligated to continue playing, even if they expressed a desire to quit. For example, participants who reported they "did not want to abandon/let other players down" were identified as having experienced social pressures, while participants who reported playing to “meet new people/make new friends” were identified as having experienced social goals. These social questions are similar to those in Bijvank, Konijn, and Bushman’s (2012) Motivations for Video Game Use Scale.

Daily playing time was calculated using the total reported time spent playing videogames on traditional platforms in minutes. Minutes played before bed was calculated using the total reported playing time (in minutes) during the hour before bed. Social goals and social pressures were calculated using the total number of goals and pressures experienced. Scores could range from 0 (no social motivations) to 6. Responses were averaged for the three days that data were collected in order to create comprehensive scores. All videogame questions were administered through an online Qualtrics survey (see Appendix E).

***Sleep Better* smartphone app.** Participants used the *Sleep Better* app (Runtastic, 2016), a free smartphone app available for both Apple iOS (Apple App Store) and Android OS (Google Play Store) devices, to record sleep data. The app was used as a measure of the amount of time spent awake, in light sleep, and in deep sleep. The app uses movement in bed as a proxy for determining whether or not a participant is asleep. The app also generated a sleep efficiency score. Participants answered nine questions about their sleep using data collected by the app and entered these responses through Qualtrics (see Appendix E). These questions were answered upon awakening.

Sleep quality was derived from the sleep efficiency score generated by the smartphone app. Sleep quantity was created by adding up the total number of minutes participants spent in light sleep and in deep sleep. SOL was the amount of time the app reported that it took for the participant to fall asleep, recorded in minutes. Responses were averaged for the three days that data were collected in order to create a comprehensive score for each sleep outcome variable.

Sleep diary. A 12-question sleep diary was used to collect self-report data regarding sleep habits, duration, and quality over the course of a three-day period. Questions for the sleep diary were created from two previously existing measures (National Sleep Foundation, n.d.; USC Santa Cruz Counseling and Psychological Services, n.d.). Participants answered questions such as how long they estimated it took for them to fall asleep, how many times (if any) they awoke in the middle of the night, and reported caffeine and alcohol consumption (see Appendix E). This series of questions was completed first upon awakening.

Self-reported sleep quality was calculated by averaging two items, refreshing rating for sleep and restfulness of sleep with values ranging from 1 (poor sleep quality) to 5 (good sleep quality). Self-reported sleep quantity was calculated using the total minutes reported spent sleeping. Self-reported SOL was calculated by determining the difference between the participants' reported bedtime and when they reported falling asleep in minutes. Responses to these questions were averaged across the three-day period of the study. These questions were administered through an online Qualtrics survey.

Procedure

The study was made available to students seeking course credit through the SONA participant recruitment system after obtaining IRB approval (see Appendix F). Participants who met the inclusion criteria outlined in the screening survey (see Appendix A) received an invitation code to sign up for the study and were asked to come into the lab to provide informed consent and to complete the PSQI, MEQ, and a brief survey to assess current videogame habits and collect demographic information. Participants were told about the daily Qualtrics surveys that they would complete, including the sleep diary, reporting data from the app, and the videogame habits survey. Each survey instructed that smartphone games were not considered to be videogames. They were instructed as to when the surveys should be completed. Afterwards, participants were guided through downloading the *Sleep Better* app and were informed how to use the app. At the conclusion of this meeting, participants were given an instruction sheet reiterating how to use the sleep app and when to complete surveys, contact information for the lead researcher, and the option of obtaining a copy of the consent form. An email with the first daily survey was sent to participants shortly after leaving the lab.

Starting on the night of the briefing with the researcher, participants were tasked with reporting that day's videogame play. The following morning, participants completed the self-report sleep diary and manually entered data from the sleep app. Participants were asked to enter the data from the sleep app after completing the sleep diary in an attempt to prevent response contamination. Instructions were worded to help participants understand that their self-reported data may differ from information recorded by the app. To make sure that participants remembered to complete the survey each day, a reminder email was sent out each afternoon. This email also included the next daily survey. The participant received a reminder and completed the daily survey each day for a total of three days.

Results

Preliminary Analyses

Preliminary analyses were conducted to ensure the assumptions of normality, linearity, and homoscedasticity. Variable residuals were normally distributed and had a linear relationship with predictor variables. The variance of residuals for predicted outcomes was similar for all predicted scores indicating no patterns for spread. Since none of the assumptions were violated the use of hierarchical regression was deemed appropriate.

The correlations between the variables included in the study are presented in Table 2. Only one predictor variable (PSQI, $r = -.37$, $p = .001$) was significantly correlated with sleep quality. PSQI score was significantly correlated with sleep quantity ($r = .29$, $p = .008$). PSQI score ($r = .31$, $p = .006$), average pre-bedtime gaming ($r = .27$, $p = .014$), and social pressures ($r = .26$, $p = .022$) were significantly correlated with SOL. Low correlations between app and self-report sleep quality ($r = .10$, $p = 397$) suggested poor reliability. Paired samples *t*-tests were conducted to test for differences between self-reports of sleep outcomes and app data. All comparisons were significant. As a result, self-report data was used instead of app data for all subsequent analyses.

Due to the high proportion of non-gamers (41.3%) included in the sample, independent samples *t*-tests were conducted to test for group differences on sleep variables (sleep quality, sleep quantity, and SOL). None of the comparisons were significant.

Hypothesis 1

A hierarchical multiple regression was performed to examine if sleep quality history (PSQI), chronotype (MEQ), and videogame variables (average amount of time spent playing videogames across the day, average amount of time gaming during the hour before bed, average social goals, and average social pressures) predicted sleep quality (Boduszek, 2013; see Table 3). Sleep quality was quantified as the average of self-reported “refreshing and restfulness of sleep.” A higher score indicated better sleep quality. All variables were centered before analysis.

In the first step of the hierarchical multiple regression, the known predictors (PSQI and MEQ scores) were entered. The model explained 14.4% of variance in sleep quality, $F(2, 77) = 6.45$, $p = .003$. Only PSQI score made a significant unique contribution to the model. The average amount of time spent playing videogames across the day, average amount of time spent gaming during the hour before bed, average social goals, and average social pressures were entered in Step 2. These four variables explained an additional, although non-significant, 1.8% of the variance in sleep quality after controlling for PSQI and MEQ scores $\Delta F(4, 73) = .40$, $p = .811$. Total variance explained by this model was 16.2%, $F(6, 73) = 2.35$, $p = .040$. Only PSQI score made a significant unique contribution to the model. Interactions between social goals and social pressures with videogame playing times were added in Step 3. The interactions between both playing time variables with social pressures were removed due to multicollinearity violations. These two interactions explained an additional, although non-significant, 1.7% of the variance in sleep quality, after controlling for previous variables $\Delta F(2, 71) = .74$, $p = .480$. No moderation was detected. Total variance explained by this model was 17.9%, $F(8, 71) = 1.93$, $p = .068$. In the final adjusted model only PSQI scores were significantly negatively related to sleep quality ($B = -.16$, $\beta = -.39$, $p = .001$), indicating that a higher PSQI score was related to poorer sleep quality.

Hypothesis 2

A similar hierarchical multiple regression was performed to examine if sleep quality history, chronotype, and videogame variables predicted sleep quantity (see Table 4). Sleep quantity was calculated using the total average minutes reported spent sleeping. All variables were centered before analysis.

In the first step of the hierarchical multiple regression, the known predictors (PSQI and MEQ scores) were entered. The model explained 9.2% of variance in sleep quantity, $F(2, 77) = 3.92$, $p = .024$. Only PSQI score made a significant unique contribution to the model. The average amount of time spent playing videogames across the day, average amount of time spent gaming during the hour before bed, average social goals, and average social pressures were entered in Step 2. These four variables explained an additional, but non-significant, 4.4% of the variance in sleep quantity, after controlling for PSQI and MEQ scores, $\Delta F(4, 73) = .93$, $p = .452$. Total variance explained by this model was 13.6%, $F(6, 73) = 1.92$, $p = .089$. Only PSQI score made a significant unique contribution to the model. Interactions between social goals and social pressures with videogame playing times were added in Step 3. The interactions between both playing time variables with social pressures were removed due to multicollinearity violations. These two interactions explained an additional, although non-significant, .4% of the variance in sleep quantity, after controlling for previous variables $\Delta F(2, 71) = .15$, $p = .864$. No moderation was detected. Total variance explained by this model was 14%, $F(8, 71) = 1.45$, $p = .193$. In the final adjusted model only PSQI scores were significantly positively related to sleep quantity (B = 16.58, $\beta = .31$, $p = .007$), indicating that a higher PSQI score was related to increased sleep quantity.

Hypothesis 3

A similar hierarchical multiple regression was performed to examine if sleep quality history, chronotype, and videogame variables predicted SOL (see Table 5). Average SOL was calculated by determining the difference between the participants' reported bedtime and when they reported falling asleep in minutes. All variables were centered before analysis.

In the first step of the hierarchical multiple regression, the known predictors (PSQI and MEQ scores) were entered. The model explained 10.3% of variance in SOL, $F(2, 77) = 4.40$, $p = .015$. Only PSQI score made a significant unique contribution to the model. The average amount of time spent playing videogames across the day, average amount of time spent gaming during the hour before bed, average social goals, and average social pressures were entered in Step 2. These four variables significantly explained an additional 12.3% of the variance in SOL, after controlling for PSQI and MEQ scores, $\Delta F(4, 73) = 2.90$, $p = .027$. Average pre-bedtime gaming contributed more additional variance ($\beta = .27$, $p = .083$) for SOL than average daily gaming ($\beta = .19$, $p = .164$). Total variance explained by this model was 16.2%, $F(6, 73) = 3.55$, $p = .004$. Only PSQI score made a significant unique contribution to the model. Interactions between social goals and social pressures with videogame playing times were added in Step 3. The interactions between both playing time variables with social pressures were removed due to multicollinearity violations. These two interactions explained an additional, although non-significant, 2% of the variance in SOL, after controlling for previous variables $\Delta F(2, 71) = .96$, $p = .387$. No moderation was detected. Total variance explained by this model was 24.6%, $F(8, 71) = 2.90$, $p = .007$. In the final adjusted model only two of the six predictor variables were significant. PSQI scores were significantly positively related to SOL (B = 2.67, $\beta = .32$, $p = .003$), indicating that a higher PSQI score was related to increased SOL. Average pre-bedtime gaming was significantly positively related to SOL (B = .85, $\beta = .39$, $p = .045$), indicating that spending more time playing videogames during the hour before bed was related to increased SOL.[1]

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[1] Additional analyses performed on only gamers revealed no significant differences in moderation for gamers

Discussion

The current study assessed the relationships between videogame playing times, social interactions, and sleep outcomes. Longer average daily and pre-bedtime playing times were hypothesized to predict decreases in sleep quality and quantity and increases in SOL when controlling for sleep quality history and morningness/eveningness. Experiencing social goals and/or pressures were expected to moderate these relationships. The results partially supported these hypotheses.

Recent research has focused on player motivations to better understand videogame behaviors across a variety of contexts. With the number of multiplayer games on the rise, social motivations are increasingly viewed as a predominant motivation for videogame play (Entertainment Software Association, 2017b). Current statistics indicate that most gamers play with others or play multiplayer games (Entertainment Software Association, 2017b).

Previous research has found that gamers often continue playing videogames during a session due to experiencing social goals or pressures (King & Delfabbro, 2009). Participants in the present study, however, rarely reported experiencing these motivations. The low rate of social motivations was unexpected since a high percentage of participants reported playing multiplayer games. Social motivations may not always be common when playing videogames. Gamer characteristics or gaming content may influence the likelihood of their occurrence. The gender makeup of participants may affect differences in social motivations. In this study, women reported spending significantly less time playing videogames both across the day and before bed than men, consistent with previous findings (Entertainment

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(all *p*s > .05). Regressions remained significant when exclusively predicting sleep quality and sleep quantity for gamers (*p*s > .05), however, results became non-significant when predicting SOL (*p*s < .05).

Software Association, 2017b). Women were also significantly less likely to report experiencing social goals. But, there were no gender differences for social pressures among this sample. However, having a large proportion of female participants in the sample may partially explain why social motivations did not moderate the relationship between videogame playing times and sleep outcomes.

Previous research primarily focused on videogame playing times when assessing the affects of videogames on sleep. Thus, both spending more time playing videogames across the day and during the hour before bed were hypothesized to predict worse sleep quality, reduced sleep quantity, and increased SOL. The relationship between the amount of time spent playing videogames and sleep outcomes is thought to be affected by the timing of gameplay (Wolfe et al., 2014), with videogame play before bedtime affecting sleep more than in the afternoon.

In the present study, longer average daily playing times did not significantly predict changes in sleep quality, quantity, or SOL. This is inconsistent with research by Arora and colleagues (2014) who found that videogame playing contributed to significantly longer SOLs and shorter sleep durations than the use of other devices (i.e., TVs, cell phones, and computers). Similarly, King and colleagues (2013) found that prolonged gaming results in reduced sleep quantity and worse sleep quality compared to shorter gaming duration. Lengthy gameplay sessions are thought to desensitize players (i.e., become less arousing) and result in less impact on sleep (Ivarsson et al., 2013). If more time spent gaming has a desensitizing effect, gameplay session length is less likely to predict sleep outcomes. This may explain why videogame playing times did not predict sleep outcomes without the contribution of other variables (i.e., participant characteristics). However, Ivarsson et al.'s (2013) desensitization theory does not consider whether the timing of gameplay matters.

Of the videogame variables, average pre-bedtime gaming was a better predictor of sleep outcomes than average daily gaming. Longer average pre-bedtime gaming times did not significantly predict sleep quality or quantity. However, consistent with previous research (Arora et al., 2014; Weaver et al., 2010), longer average pre-bedtime gaming did predict SOL. This suggests that the timing of gameplay may be more important than the amount of time spent playing videogames. Pre-bedtime gaming may be more problematic than gameplay session length due to increased excitement/arousal before bed (Foley et al., 2013). This contradicts Ivarsson and colleagues (2013) desensitization theory, suggesting that desensitization may not accurately explain the relationship between playing times and sleep onset latency.

Previous research has indicated that many people play videogames during the hour before bed (Foley et al., 2013; Pieters et al., 2014). Pre-bedtime gaming was not common in this sample. A person's age may influence the likelihood that they play videogames before bed. Prior studies have found that older adolescents are more likely than children to report using any kind of electronic device – including videogames – during the hour leading up to bedtime (Foley et al., 2013). This suggests that college students would be more likely to engage in pre-bedtime gaming, but the results of the current study did not suggest that this is common for traditional gaming. Smartphone gaming may be more common before bedtime among this age group than traditional gaming due to the portability of the device. However, there is no research addressing this possibility and the current study did not include cell phone gaming.

Participant gender may have impacted the results of the study. Most previous videogame research has focused exclusively on male participants (Ivarsson et al., 2013; King et al., 2013; Weaver et al., 2010), while the present study had a majority of female participants. In general, men report spending more time playing videogames and less time sleeping than women (Wolfe et al., 2014). The current study found that men reported playing videogames significantly longer across the day and during the hour before bed. However, no gender differences were identified for sleep outcomes. Ogletree and Drake (2007) found that women gamers were less likely to report that videogames interfered with their sleep than men. More studies should delve into potential gender differences in videogame and sleep habits.

Participant characteristics were also expected to predict sleep outcomes. Poor average sleep quality history was expected to predict worse sleep quality, reduced sleep quantity, and increased SOL. Previous research has shown that the PSQI is more strongly correlated with sleep quality than sleep quantity (Pilcher et al., 1997). Results of the present study supported this finding. Average sleep quality history significantly predicted sleep quality and SOL in the expected direction. However, an unexpected relationship emerged for sleep quantity, with worse sleep quality history predicting significantly greater sleep quantity. This suggests that participants who perceive a poor quality of sleep may attempt to remedy the situation by spending more time in bed. The positive relationship between sleep quantity and PSQI was inconsistent with previous studies that found a weak negative relationship between the two variables (Pilcher et al., 1997).

Previous research with college students has found that between 41.4% (Li et al., 2016) and 60% (Mesquita & Reimão, 2010) of participants reported poor sleep quality. In the present study, all participants had poor sleep quality, resulting in low variability in participant sleep quality history. This created a floor effect for sleep quality history responses, making it less likely that the other variables (i.e., participant characteristics and playing times) in the regressions would be able to predict sleep outcomes. Thus, the results of the present study likely cannot be generalized to good sleepers. Gamers did report somewhat of a worse sleep quality history than non-gamers, but this difference was not significant. The poor sleep quality history of participants is consistent with data suggesting that college students often exhibit poor sleep hygiene habits (e.g., not going to bed at a consistent time) that may reduce sleep quality (Li et al., 2016; Vollmer et al., 2017). However, the percentage of poor sleepers identified in the current study was not consistent with the number of poor sleepers identified in previous research (Li et al., 2016; Vollmer et al., 2017). Self-reporting sleep quality history may introduce participant bias, resulting in participants exaggerating the quality of their sleep. This may explain inconsistencies in the proportion of poor sleepers identified across studies. However, measurements of sleep quality from the sleep app were unreliable when compared to self-reports. Sleep quality may be a construct that is best measured using self-reports. Additional studies may consider assessing the reliability of other physiological measures (e.g., EEG) compared to self-reports and sleep apps.

Morningness/eveningness was also treated as a likely predictor of sleep outcomes based on previous research (Milada et al., 2011; Vitale et al., 2015). Participants who were identified as evening oriented did not, as expected, report worse sleep outcomes. Previous findings are inconsistent. Vollmer and colleagues (2017) found that morningness/eveningness predicted sleep quantity, but not sleep quality. Most of the participants in the current study were not classified as morning or evening type (i.e., "neither" type), which is consistent with previous research (Milada et al., 2011; Vitale et al., 2015). Gamers were more likely to be identified as evening type than non-gamers, however, this difference was not significant.

Strengths, Limitations, and Directions for Future Research

The present study had several methodological strengths and weaknesses. Not allowing participants to report gameplay on smartphones was a major limitation. Videogame research traditionally focuses on the use of standard videogame consoles or games played on a computer. Failure to include games played on a smartphone in this study may have resulted in participants having to exclude a portion of time spent playing videogames, particularly since participants were required to take their phone to bed. Shorter playing times overall and during the hour before bed may have been reported as a result. Average videogame habits may be changing as a result of people playing games on smartphones. There is currently no research on smartphone gaming habits. Future studies should include games played on a variety of platforms, including smartphones.

The unreliability of the *Sleep Better* smartphone app was another limitation, although the present study relied upon self-report data which is generally considered valid (Lauderdale et al., 2008). Analyses indicated that self-reports of sleep quality were weakly correlated with app data and *t*-test comparisons revealed that self-reports for all sleep outcomes were significantly different from the app reports. This suggests that the app did not measure sleep outcomes consistent with participants' perceptions of their sleep quality. Little empirical evidence currently exists assessing the effectiveness of using a smartphone to measure sleep outcomes. Future studies should assess easy to use alternatives for obtaining objective measures of sleep outcomes in a home environment.

The present study was also limited by the sample used. Gamers and non-gamers were allowed to participate in the study, which may have weakened observed relationships. Non-gamers contributed no variability for playing times or social motivations. Future studies should only recruit gamers to increase the likelihood of finding relationships between videogame variables and sleep outcomes. Similarly, although roughly 70% of gamers are above the age of 18, a college-aged sample is not entirely representative of gamers; the average gamer is 34 years old (Entertainment Software Association, 2017b). This limits the generalizability of the results to children, adolescents, and non-college aged adults. The strength of relationships between videogame playing times and sleep outcomes may depend on age. Previous research has implicated that children's sleep is more strongly impacted by videogames than adolescents or adults (Wolfe et al., 2014). Social motivations may moderate the relationship between playing times and sleep outcomes for specific age populations similar to playing times. However, research on social motivations has focused on adults and in areas other than sleep (King & Delfabbro, 2009; Snodgrass et al., 2013; Tan et al., 2017). Future studies should test for possible age group differences.

Generalizability of results may have been limited by the inclusion criteria of this study. Only participants who owned a smartphone were allowed to participate. Recent statistics indicate that 95% of Americans own a cellphone, while 77% own a smartphone (Pew Research Center, 2018). People who do not own smartphones may have better sleep hygiene than people who own a smartphone. Although research has shown that using a smartphone before bed is related to longer SOLs and shorter sleep duration (Hysing et al., 2015; Pieters et al., 2014), there are no studies comparing sleep outcomes between smartphone owners and non-smartphone owners. Therefore, we do not know if non-smartphone owners are significantly different from the sample used.

Additionally, results of the current study might not generalize to good sleepers. No good sleepers were identified in the sample, resulting in range restriction for PSQI scores. Researchers should attempt to have a sample consisting of both good and poor sleepers. In order to create a more representative sample, steps should be taken to try increasing the likelihood of recruiting good sleepers. Future studies should seek participants with diverse sleep hygiene habits and ask participants about their perceived sleep quality before recruitment.

This study was also limited by not asking participants detailed questions about their gaming experiences each day. For example, participants were not asked about the content of videogames they played. The genre of a game or the level of game violence may have influenced playing times, social goals/pressures, or sleep outcomes. Future studies should ask participants to report what game(s) they played to determine if game content is tied to social motivations or sleep outcomes. Game content may also moderate the relationship between playing times and sleep outcomes. More exciting or immersive games may increase playing times and result in worse sleep outcomes (Dalisay et al., 2015; Ivarsson et al., 2013; Tan et al., 2017).

Having participants report their videogame and sleep habits for multiple days was a strength. The use of a three-day data collection period was an improvement over the typical (i.e., 1-2 days) span of data collection. However, using seven days of data would be preferable for obtaining more accurate average sleep outcomes. Further, some participants reported their sleep and videogame habits for a mixture of weekdays and weekends, however others only reported weekday data, due to the timing of their initial lab visit. Having participants report videogame habits and measure sleep outcomes for a full week would allow for more accurate depictions of typical habits.

Finally, this study did not manipulate any of the observed variables or control for confounds, such as amount of time using other electronics. However, experimental studies control for a wide variety of explanatory factors (i.e., confounds). As a result, effects in the lab are usually stronger than in home environments (Wolfe et al., 2014). Participants in the present study were asked to maintain their typical behaviors. This allowed for videogame and sleep habits that better represented real-life behaviors, enhancing generalizability of obtained outcomes.

Conclusions

Previous research has demonstrated relationships between participant characteristics, videogame playing times, and sleep outcomes. The current study partially supported these findings. Participant sleep quality history was the most consistent predictor of sleep outcomes. Social goals and pressures did not moderate playing times and sleep outcomes as expected. Results indicated that higher average daily and pre-bedtime playing times did not significantly predict sleep quality or quantity, but pre-bedtime gaming did significantly predict SOL. This suggests that playing videogames impact different aspects of sleep to varying degrees. More in-home studies should be conducted to determine if these findings remain consistent, especially with a more diverse sample (e.g. age, gender).

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Tables

Table 1.

Sample Descriptive Statistics

Variable	Percentage %	*M*	*SD*	Minimum	Maximum
Gender (Female)	63.8%				
Age	-	19.24	1.02	18.00	22.00
Race/ethnicity (White)	85%				
Gamer Status (Gamer)	59%				
Baseline Playing Time	-	78.45	86.14	.00	300.00
PSQI Score	-	9.21	1.93	6.00	17.00
MEQ Score	-	47.61	7.75	33.00	69.00
Playing Time	-	60.5	86.13	.00	370.33
Minutes Before Bed	-	2.37	7.21	.00	41.67
Social Goals	-	.06	.20	.00	1.00
Social Pressures	-	.004	.04	.00	.33
Sleep Quality	-	3.15	.80	1.50	4.83
Sleep Quantity	-	449.40	102.26	266.67	1165.00
SOL	-	26.36	15.91	4.00	86.00

Note. Baseline Playing Time indicates average daily playing time reported at baseline, PSQI Score indicates Pittsburg Sleep Quality Index score, MEQ Score indicates morningness/eveningness rating, Playing Time indicates average daily playing time, Minutes Before Bed indicates average playing time during the hour before bed, Social Goals indicates average amount of social goals experienced, and Social Pressures indicates average amount of social pressures experienced.

Table 2.

Correlations between Study Variables (N = 80)

Variables	1	2	3	4	5	6	7	8	9	10	11	12
1 Self-Report Sleep Quality	1											
2 Self-Report Sleep Quantity	.09	1										
3 Self-Report SOL	–.28*	–.10	1									
4 App Sleep Quality	.10	–.05	–.13	1								
5 App Sleep Quantity	.19	.48***	.02	–.12	1							
6 App SOL	–.02	.12	.48***	–.19	.07	1						
7 PSQI Score	–.37***	.29**	.31**	–.23*	.03	.16	1					
8 MEQ Score	.11	.06	.07	.02	.13	.01	–.08	1				
9 Playing Time	–.12	–.12	.18	–.09	–.14	.18	–.04	–.14	1			
10 Minutes Before Bed	–.07	–.18	.27**	–.02	–.18	.10	.06	–.12	.46***	1		
11 Social Goals	–.04	–.19	.04	–.04	–.19	.13	–.02	–.24*	.60***	.63***	1	
12 Social Pressures	–.02	–.12	.26*	–.03	–.03	.19	–.01	.01	.27*	.47***	.15	1

Note. Statistical significance: $*p < .05$; $**p < .01$; $***p < .001$
PSQI Score indicates Pittsburg Sleep Quality Index score, MEQ Score indicates morningness/eveningness rating, Playing Time indicates average daily playing time, Minutes Before Bed indicates average playing time during the hour before bed, Social Goals indicates average amount of social goals experienced, and Social Pressures indicates average amount of social pressures experienced.

Table 3.

Hierarchical Multiple Regression Analysis Predicting Sleep Quality

	R	R^2	ΔR^2	B	SE	β	*t*
Step 1	.38	.14					
PSQI Score				–.15	.04	–.36***	–3.44
MEQ Score				.008	.01	.08	.77
Step 2	.40	.16	.02				
PSQI Score				–.15	.05	–.37***	–3.39
MEQ Score				.008	.01	.07	.67
Playing Time				–.002	.001	–.17	–1.20
Minutes Before Bed				–.003	.02	–.03	–.18
Social Goals				.35	.66	.09	.52
Social Pressures				.40	2.71	.02	.15
Step 3	.42	.18	.12				
PSQI Score				–.16	.05	–.39***	–3.49
MEQ Score				.008	.01	.08	.69
Playing Time				–.001	.001	–.09	–.61
Minutes Before Bed				–.01	.02	–.11	–.56
Social Goals				–1.33	1.72	–.33	–.78
Social Pressures				.38	2.78	.02	.14

	R	R^2	ΔR^2	B	SE	β	*t*
Playing Time X Social Goals				.005	.007	.24	.79
Minutes Before Bed X Social Goals				.05	.04	.28	1.16

Note. Statistical significance: $*p < .05$; $**p < .01$; $***p < .001$
PSQI Score indicates Pittsburg Sleep Quality Index score, MEQ Score indicates morningness/eveningness rating, Playing Time indicates average daily playing time, Minutes Before Bed indicates average playing time during the hour before bed, Social Goals indicates average amount of social goals experienced, Social Pressures indicates average amount of social pressures experienced, Playing Time X Social Goals indicates the interaction between average daily playing time and social goals, and Minutes Before Bed X Social Goals indicates the interaction between average playing time during the hour before bed and social goals.

Table 4.

Hierarchical Multiple Regression Analysis Predicting Sleep Quantity

	R	R^2	ΔR^2	B	SE	β	*t*
Step 1	.30	.09					
PSQI Score				15.84	5.76	.30**	2.75
MEQ Score				1.05	1.44	.08	.73
Step 2	.37	.14	.04				
PSQI Score				16.04	5.82	.30**	2.78
MEQ Score				.59	1.49	.05	.40
Playing Time				.05	.17	.04	.30
Minutes Before Bed				–1.73	2.28	–.12	–.76
Social Goals				–57.69	86.26	–.11	–.67
Social Pressures				–142.68	352.36	–.05	–.41
Step 3	.37	.14	.004				
PSQI Score				16.58	5.98	.31**	2.77
MEQ Score				.55	1.51	.04	.36
Playing Time				.01	.19	.01	.04
Minutes Before Bed				–.95	2.88	–.07	–.33
Social Goals				11.02	225.62	.02	.05
Social Pressures				–157.73	364.87	–.06	–.43

	R	R^2	ΔR^2	B	SE	β	*t*
Playing Time X Social Goals				–.14	.87	–.05	–.17
Minutes Before Bed X Social Goals				–2.99	5.54	–.13	–.54

Note. Statistical significance: $*p < .05$; $**p < .01$; $***p < .001$
PSQI Score indicates Pittsburg Sleep Quality Index score, MEQ Score indicates morningness/eveningness rating, Playing Time indicates average daily playing time, Minutes Before Bed indicates average playing time during the hour before bed, Social Goals indicates average amount of social goals experienced, Social Pressures indicates average amount of social pressures experienced, Playing Time X Social Goals indicates the interaction between average daily playing time and social goals, and Minutes Before Bed X Social Goals indicates the interaction between average playing time during the hour before bed and social goals.

Table 5.

Hierarchical Multiple Regression Analysis Predicting Sleep Onset Latency (SOL)

	R	R^2	ΔR^2	B	SE	β	*t*
Step 1	.32	.10					
PSQI Score				2.58	.89	.31**	2.90
MEQ Score				.19	.22	.09	.86
Step 2	.48	.23	.12				
PSQI Score				2.48	.86	.30**	2.89
MEQ Score				.20	.22	.10	.92
Playing Time				.03	.03	.19	1.41
Minutes Before Bed				.59	.34	.27	1.76
Social Goals				–18.37	12.71	–.23	–1.45
Social Pressures				50.84	51.90	.12	.97
Step 3	.50	.25	.02				
PSQI Score				2.67	.87	.32**	3.06
MEQ Score				.19	.22	.09	.86
Playing Time				.02	.03	.10	.69
Minutes Before Bed				.85	.42	.39*	2.04
Social Goals				11.89	32.86	.15	.36
Social Pressure				47.10	53.14	.11	.89

	R	R^2	ΔR^2	B	SE	β	*t*
Playing Time X Social Goals				–.08	.13	–.18	–.61
Minutes Before Bed X Social Goals				–1.12	.81	–.32	–1.34

Note. Statistical significance: $^*p < .05$; $^{**}p < .01$; $^{***}p < .001$
PSQI Score indicates Pittsburg Sleep Quality Index score, MEQ Score indicates morningness/eveningness rating, Playing Time indicates average daily playing time, Minutes Before Bed indicates average playing time during the hour before bed, Social Goals indicates average amount of social goals experienced, Social Pressures indicates average amount of social pressures experienced, Playing Time X Social Goals indicates the interaction between average daily playing time and social goals, and Minutes Before Bed X Social Goals indicates the interaction between average playing time during the hour before bed and social goals.

Figures

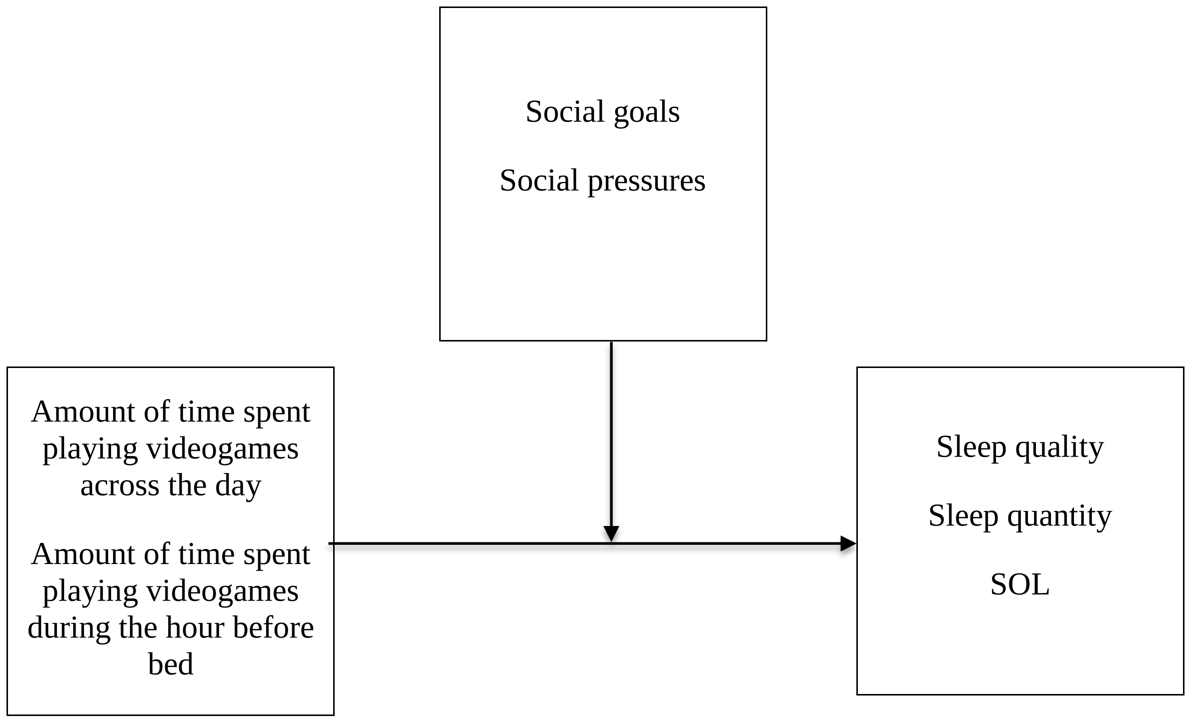

Figure 1. Moderating role of social goals and social pressures between videogame variables and sleep outcomes

Appendix A

Screening Survey

Thank you for your interest in our study. The following questions are to determine if you are a good fit for our study.

1. Do you own a smartphone that runs Apple iOS or Android OS?

❍ Yes

❍ No

2. Would you be willing to download an app on your smartphone for the purposes of our study?

❍ Yes

❍ No

3. Are you currently using any sleep aids or medication in order to help you sleep at night (e.g. melatonin, Lunesta, Ambien, etc.)?

❍ Yes

❍ No

4. Have you ever been or are you currently diagnosed with a sleep-related disorder (e.g. insomnia, narcolepsy)?

❍ Yes

❍ No

Appendix A (continued)

5. Do you regularly share a bed with another individual (e.g. partner, child, etc.)?

- Never
- Sometimes
- Most times
- Always

6. How often do you go to bed within an hour of your typical bedtime and wake up within an hour of your typical wake time? For example, if you usually go to bed at 11:00 p.m. on Wednesday and wake up at 8:30 a.m. Thursday morning, you would meet this criteria if you went to bed as early as 10:00 p.m. or as late as 12:00 a.m. and woke up as early as 7:30 a.m. or as late as 9:30 a.m. the following morning.

- Never
- Sometimes
- Most times
- Always

Appendix B

Demographics

Thank you for agreeing to participate in our study. Please read each question carefully and answer to the best of your ability; there are no wrong answers. To get started, we will first ask you a couple of questions about yourself.

What is the identification number that was assigned to you? ____________________

1. Which race/ethnicity do you most identify as?

❍ African American

❍ White/Caucasian

❍ Asian American

❍ Native American

❍ Hispanic American

❍ Other ____________________

❍ Prefer not to say

2. Which gender do you most identify as?

❍ Male

❍ Female

❍ Transgender

3. What is your age? ___________

Appendix B (continued)

Now we would like to ask you a few questions about some of your habits. When referring to videogames, we mean playing games on a standard home console (e.g. Xbox), portable dedicated gaming system (e.g. 3DS), or laptop/computer. Please do not include games played on a smartphone when answering these questions.

4. Thinking of the two-three hour period before you go to bed, how often do you...

	Never	Sometimes	About half the time	Most of the time	Always
Consume caffeine before bed?	❍	❍	❍	❍	❍
Exercise before bed?	❍	❍	❍	❍	❍
Play videogames before bed?	❍	❍	❍	❍	❍
Use other electronics before bed?	❍	❍	❍	❍	❍

5. On average, how much time (in hours and minutes) do you spend playing videogames each day?

Hours: ____________

Minutes: ____________

6. Have you ever lost track of time as a result of playing videogames?

❍ Yes

❍ No

Appendix C

Pittsburg Sleep Quality Index (PSQI)

The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days and nights in the past month. Please answer all questions.

What is the identification number that was assigned to you? ________________

1. During the past month, what time have you usually gone to bed at night?

Hour: ______

Minute: ______

AM/PM: ______

2. During the past month, how long (in minutes) has it usually taken you to fall asleep each night?

Minutes: ______

3. During the past month, what time have you usually gotten up in the morning?

Hour: _____

Minute: _____

AM/PM: _____

4. During the past month, how many hours of actual sleep did you get at night? (This may be different than the number of hours you spent in bed.)

Hours: _____

For each of the remaining questions, check the one best response. Please answer all questions.

Appendix C (continued)

5. During the past month, how often have you had trouble sleeping because you . . .

	Not during the past month	Less than once a week	Once or twice a week	Three or more times a week
Cannot get to sleep within 30 minutes	❍	❍	❍	❍
Wake up in the middle of the night or early morning	❍	❍	❍	❍
Have to get up to use the bathroom	❍	❍	❍	❍
Cannot breathe comfortably	❍	❍	❍	❍
Cough or snore loudly	❍	❍	❍	❍
Feel too cold	❍	❍	❍	❍
Feel too hot	❍	❍	❍	❍
Had bad dreams	❍	❍	❍	❍
Have pain	❍	❍	❍	❍

6. During the past month, how would you rate your sleep quality overall?

❍ Very good

❍ Fairly good

❍ Fairly bad

❍ Very bad

Appendix C (continued)

7. During the past month, how often have you taken medicine to help you sleep (prescribed or "over the counter")?

❍ Not during the past month

❍ Less than once a week

❍ Once or twice a week

❍ Three or more times a week

8. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?

❍ Not during the past month

❍ Less than once a week

❍ Once or twice a week

❍ Three or more times a week

9. During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?

❍ No problem at all

❍ Only a very slight problem

❍ Somewhat of a problem

❍ A very big problem

Appendix D

Morningness-Eveningness Questionnaire (MEQ)

Please read each question very carefully before answering. Please answer each question as honestly as possible. Answer ALL questions. Each question should be answered independently of others. Do NOT go back and check your answers.

What is the identification number that was assigned to you? _______________

1. What time would you get up if you were entirely free to plan your day?

- 5:00 AM – 6:30 AM (5)
- 6:30 AM – 7:45 AM (4)
- 7:45 AM – 9:45 AM (3)
- 9:45 AM – 11:00 AM (2)
- 11:00 AM – 12 NOON (1)
- 12 NOON – 5:00 AM (0)

2. What time would you go to bed if you were free to plan your evening?

- 8:00 PM – 9:00 PM (5)
- 9:00 PM – 10:15 PM (4)
- 10:15 PM – 12:30 AM (3)
- 12:30 AM – 1:45 AM (2)
- 1:45 AM – 3:00 AM (1)
- 3:00 AM – 8:00 PM (0)

Appendix D (continued)

3. If there is a specific time at which you have to get up in the morning, to what extent do you depend on being woken up by an alarm clock?

- Not at all dependent (4)
- Slightly dependent (3)
- Fairly dependent (2)
- Very dependent (1)

4. How easy do you find it to get up in the morning (when you are not woken up unexpectedly)?

- Not at all easy (1)
- Not very easy (2)
- Fairly easy (3)
- Very easy (4)

5. How alert do you feel during the first half-hour after you wake up in the morning?

- Not at all alert (1)
- Slightly alert (2)
- Fairly alert (3)
- Very alert (4)

6. How hungry do you feel during the first half-hour after you wake up in the morning?

- Not at all hungry (1)
- Slightly hungry (2)
- Fairly hungry (3)
- Very hungry (4)

Appendix D (continued)

7. During the first half-hour after you wake up in the morning, how tired do you feel?

❍ Very tired (1)

❍ Fairly tired (2)

❍ Fairly refreshed (3)

❍ Very refreshed (4)

8. If you have no commitments the next day, what time would you go to bed compared to your usual bedtime?

❍ Seldom or never later (4)

❍ Less than one hour later (3)

❍ 1-2 hours later (2)

❍ More than two hours later (1)

9. You have decided to engage in some physical exercise. A friend suggests that you do this for one hour twice a week and the best time for him is between 7:00 AM – 8:00 AM. Bearing in mind nothing but your own internal "clock", how do you think you would perform?

❍ Would be in good form (4)

❍ Would be in reasonable form (3)

❍ Would find it difficult (2)

❍ Would find it very difficult (1)

Appendix D (continued)

10. At what time of day do you feel you become tired as a result of need for sleep?

- 8:00 PM – 9:00 PM (5)
- 9:00 PM – 10:15 PM (4)
- 10:15 PM – 12:45 AM (3)
- 12:45 AM – 2:00 AM (2)
- 2:00 AM – 3:00 AM (1)

11. You want to be at your peak performance for a test that you know is going to be mentally exhausting and will last for two hours. You are entirely free to plan your day. Considering only your own internal "clock", which ONE of the four testing times would you choose?

- 8:00 AM – 10:00 AM (4)
- 11:00 AM – 1:00 PM (3)
- 3:00 PM – 5:00 PM (2)
- 7:00 PM – 9:00 PM (1)

12. If you go to bed at 11:00 PM, how tired would you be?

- Not at all tired (1)
- A little tired (2)
- Fairly tired (3)
- Very tired (4)

Appendix D (continued)

13. For some reason you have gone to bed several hours later than usual, but there is no need to get up at any particular time the next morning. Which ONE of the following are you most likely to do?

❍ Will wake up at usual time, but will NOT fall back asleep (4)

❍ Will wake up at usual time and will doze thereafter (3)

❍ Will wake up at usual time but will fall asleep again (2)

❍ Will NOT wake up until later than usual (1)

14. One night you have to remain awake between 4:00 AM – 6:00 AM in order to carry out a night watch. You have no commitments the next day. Which ONE of the alternatives will suit you best?

❍ Would NOT go to bed until watch was over (1)

❍ Would take a nap before and sleep after (2)

❍ Would take a good sleep before and a nap after (3)

❍ Would sleep only before watch (4)

15. You have to do two hours of hard physical work. You are entirely free to plan your day and considering only your own internal “clock” which ONE of the following times would you choose?

❍ 8:00 AM – 10:00 AM (4)

❍ 11:00 AM – 1:00 PM (3)

❍ 3:00 PM – 5:00 PM (2)

❍ 7:00 PM – 9:00 PM (1)

Appendix D (continued)

16. You have decided to engage in hard physical exercise. A friend suggests that you do this for one hour twice a week and the best time for him is between 10:00 PM – 11:00 PM Bearing in mind nothing else but your own internal "clock" how well do you think you would perform?

- ❍ Would be in good form (1)
- ❍ Would be in reasonable form (2)
- ❍ Would find it difficult (3)
- ❍ Would find it very difficult (4)

17. Suppose that you can choose your own work hours. Assume that you worked a FIVE hour day (including breaks) and that your job was interesting and paid by results. Which FIVE CONSECUTIVE HOURS would you select?

- ❍ 5 hours starting between 4:00 AM and 8:00 AM (5)
- ❍ 5 hours starting between 8:00 AM and 9:00 AM (4)
- ❍ 5 hours starting between 9:00 AM and 2:00 PM (3)
- ❍ 5 hours starting between 2:00 PM and 5:00 PM (2)
- ❍ 5 hours starting between 5:00 PM and 4:00 AM (1)

18. At what time of day do you think that you reach your "feeling best" peak?

- ❍ 5:00 AM – 8:00 AM (5)
- ❍ 8:00 AM – 10:00 AM (4)
- ❍ 10:00 AM – 5:00 PM (3)
- ❍ 5:00 PM – 10:00 PM (2)
- ❍ 10:00 PM – 5:00 AM (1)

Appendix D (continued)

19. One hears about "morning" and "evening" types of people. Which ONE of these types do you consider yourself to be?

- ❍ Definitely a "morning" type (6)
- ❍ Rather more a "morning" type than an "evening" type (4)
- ❍ Rather more an "evening" type than a "morning" type (2)
- ❍ Definitely an "evening" type (0)

SCORING:

The score for each response is beside each answer choice. Total your scores and compare them to the scale below.

Definitely Morning Type	70-86
Moderately Morning Type	59-69
Neither Type	42-58
Moderately Evening Type	31-41
Definitely Evening Type	16-30

Appendix E

Videogame and Sleep Habits

This portion of the survey will ask you questions regarding your behaviors for the day and should be completed at the end of the day prior to going to bed. When referring to videogames,

we mean playing games on a standard home console (e.g. Xbox), portable dedicated gaming system (e.g. 3DS), or laptop/computer. Please do not include games played on a smartphone when answering these questions. Please read each question carefully and answer to the best of your ability.

What is the identification number that was assigned to you? ________________

1. How much time (in hours and minutes) did you spend playing videogames today?

Hours: __________

Minutes: __________

Display This Question:

If How much time (in hours and minutes) did you spend playing videogames today? Hours Is Not Equal to 0

Or How much time (in hours and minutes) did you spend playing videogames today? Minutes Is Not Equal to 0

2. Did you play any multiplayer or online games?

❍ Yes

❍ No

Appendix E (continued)

Display This Question:

If How much time (in hours and minutes) did you spend playing videogames today? Hours Is Not Equal to 0

Or How much time (in hours and minutes) did you spend playing videogames today? Minutes Is Not Equal to 0

3. Did you delay your bedtime in order to play videogames?

❍ Yes

❍ No

Display This Question:

If Did you delay your bedtime in order to play videogames? Yes Is Selected

4. Why did you delay your bedtime in order to play videogames? Select all that apply.

❑ Social pressure to continue playing

❑ Social goals (e.g. wanting to continue playing with friends)

❑ Lost track of time

❑ Wanted to complete an in-game task (e.g. level up, finish quest)

❑ Other ____________

Display This Question:

If Why did you delay your bedtime in order to play videogames? Social pressure to continue playing Is Selected

Appendix E (continued)

5. What kind(s) of social pressure(s) motivated you to delay your bedtime? Select all that apply.

- ❑ Other players urged me to continue playing
- ❑ Didn't want to abandon/let other players down
- ❑ Other: ______________

Display This Question:

If Why did you delay your bedtime in order to play videogames? Social goals Is Selected

6. What kind(s) of social goal(s) motivated you to delay your bedtime? Select all that apply.

- ❑ Meet new people/make new friends
- ❑ Play with friends
- ❑ Other: _____________

Display This Question:

If Did you delay your bedtime in order to play videogames? Yes Is Selected

Appendix E (continued)

7. Why did you stop playing videogames and go to bed? Select all that apply.

- ❑ I was too tired to continue playing
- ❑ I needed to get up early
- ❑ I was no longer interested in playing anymore
- ❑ My friends were no longer online
- ❑ Other: __________

8. What electronics did you use within an hour of going to bed? Select all that apply.

- ❑ Videogame console/handheld
- ❑ TV
- ❑ Laptop/computer
- ❑ Cell phone
- ❑ Tablet/e-reader
- ❑ Other ______________________
- ❑ None

Display This Question:

If What electronics did you use within an hour of going to bed? Select all that apply. Videogame console/handheld Is Selected

9. How much time (in minutes) did you spend playing videogames within an hour of going to bed?

Minutes: __________

Appendix E (continued)

In this section, we will ask you to report on some of your sleeping habits from last night. This section should be completed as soon as possible upon awakening. Please read each question carefully and try to answer to the best of your ability.

10. What time did you officially go to bed for the night (with the intention to sleep)?

Hour: ______________

Minute: ________________

AM/PM: _______________

11. What time did you fall asleep after going to bed for the night?

Hour: _____________

Minute: _______________

AM/PM: ______________

12. How many times did you wake up in the middle of the night?

- ❍ 0
- ❍ 1
- ❍ 2
- ❍ 3
- ❍ 4+

Appendix E (continued)

13. How much time (in hours and minutes) would you estimate that you were awake during the night?

Hours: _____________

Minutes: ______________

14. At what time did you wake up in the morning?

Hour: ______________

Minute: _______________

AM/PM: ______________

15. How much time (in hours and minutes) would you estimate that you spent sleeping last night?

Hours: ______________

Minutes: _______________

16. How did you feel when you woke up this morning?

	Fatigued	Somewhat fatigued	Neither fatigued nor refreshed	Somewhat refreshed	Refreshed
I felt…	•	•	•	•	•

17. How restful would you categorize your sleep considering factors such as tossing and turning, awakenings, and feelings of tension?

	Restless	Somewhat restless	Neither restless nor restful	Somewhat restful	Restful
My sleep was…	•	•	•	•	•

Appendix E (continued)

18. Did you consume caffeine within two-three hours of going to bed?

❍ Yes

❍ No

19. Did you exercise for at least 20 minutes within two-three hours of going to bed?

❍ Yes

❍ No

20. Did you consume alcohol within two-three hours of going to bed?

❍ Yes

❍ No

❍ Prefer not to answer

21. Did you intake nicotine within two-three hours on going to bed?

❍ Yes

❍ No

In this section, we will ask you to report the data obtained from the *Sleep Better* app on your smartphone. Please copy the information down exactly as it is presented. If you are unfamiliar with how to find the information requested in a question, please refer to the instruction sheet that was given to you. The data presented in the app may differ slightly from your previous self-report. Please do not go back and change previous answers.

22. What time did the app start recording you sleeping?

Hour: ____________

Minute: ____________

AM/PM: ___________

Appendix E (continued)

23. What time did the app stop recording you sleeping?

Hour: ____________

Minute: _____________

AM/PM: ____________

24. How long (in minutes) did it take for you to fall asleep?

Minutes: _____________

25. What was the total amount of time (in hours and minutes) spent in bed?

Hours: _____________

Minutes: ______________

26. What was the total time (in hours and minutes) spent awake?

Hours: _____________

Minutes: ______________

27. What was the total time (in hours and minutes) spent in light sleep?

Hours: ______________

Minutes: _______________

28. What was the total time (in hours and minutes) spent in deep sleep?

Hours: ______________

Minutes: _______________

29. What was your obtained sleep efficiency score? Please enter the number only.

____

Appendix E (continued)

30. Before going to bed, did you... Select all that apply.

- ❑ Work out?
- ❑ Have a stressful day?
- ❑ Sleep in a different bed?
- ❑ Eat late?
- ❑ Consume caffeine?
- ❑ Consume alcohol?
- ❑ Intake nicotine?
- ❑ None

Appendix F

Appalachian STATE UNIVERSITY

INSTITUTIONAL REVIEW BOARD
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To: Amanda Hudson
Psychology
CAMPUS EMAIL

From: Dr. Andrew Shanely, IRB Chairperson
Date:
RE: Notice of IRB Approval by Expedited Review (under 45 CFR 46.110)
Agrants #:
Grant Title:

STUDY #: 18-0149
STUDY TITLE: Play Hard, Sleep Harder: Relationship between Time Spent Playing Videogames and Sleep
Submission Type: Initial
Expedited Category: (7) Research on Group Characteristics or Behavior, or Surveys, Interviews, etc.
Approval Date: 1/17/2018
Expiration Date of Approval: 1/16/2019

The Institutional Review Board (IRB) approved this study for the period indicated above. The IRB found that the research procedures meet the expedited category cited above. IRB approval is limited to the activities described in the IRB approved materials, and extends to the performance of the described activities in the sites identified in the IRB application. In accordance with this approval, IRB findings and approval conditions for the conduct of this research are listed below.

Vita

Amanda Nicole Hudson was born in Virginia Beach, Virginia, to Jim and Lauri Hudson. She graduated from Ocean Lakes High School in May 2012. Later that year she entered James Madison University to study Psychology and was awarded a Bachelor of Science in the fall of 2015. She accepted a research assistantship in Experimental Psychology at Appalachian State University and began study towards a Master of Arts degree. The M.A. was awarded August 2018. In the fall of 2018, Amanda continued her education at Washington State University in pursuance of a Ph.D. in Experimental Psychology with a concentration in Cognitive Psychology.